Cramer was at Cape Chidley we attempted hourly communication with that station, and to the extent that fading entered in our efforts were successful in this. Cramer lost his plane at Cape Chidley, but on July 14, the day set for his arrival at Mount Evans, I find these notes, "This was the best day of the summer—clear sky, light surface winds, and moderate southwest wind aloft." A year earlier, when Hassell was expected, practically similar conditions prevailed.

In concluding this paper, I ought to relate our extreme temperatures. Winter's coldest was 41° below zero, while the maximum of the two summers was 70.1. One clear day, with a piece of black cloth, I coaxed the mercury up to 119°.

SUBSOIL MOISTURE AND CROPS FOR 1931

By HENRY C. SNYDER

[Weather Bureau Office, Denver, Colo.]

The dryness and extreme heat of 1930 were so unusual as to justify extra precautions in farming operations in 1931. In many instances wells and springs became dry that had never failed before, indicating that the subsoil water has been depleted to a dangerous point, when considering crop production for 1931. A short, dry period, such as is more or less common in the regions affected by the 1930 drought, would have more than the usual effect and cause an apparent unaccountable damage this year unless the depletion of stored moisture is considered.

It is practically certain that the drought area benefited little by hygroscopic moisture during the past winter months, and with a constant drain on capillary water for so long the outlook is very unfavorable. Water from the permanent water level may have helped some, but with our present knowledge of capillarity it seems that the subsoil could have benefited little from this source of moisture, as it is largely beyond reach. Under artificial conditions, capillarity has been known to extend 10 feet, but this required some 18 months, and the permanent water level is much deeper than this. With regard to soil moisture, the warmth of the past winter was also detrimental, in causing more than normal evaporation. Colder weather would have been beneficial in checking evaporation and thereby holding in check the capillary water that did reach near-surface depths. The results of a cold snap in spring illustrates the point. When this occurs there is a decidedly moist layer of earth a few inches below the surface, caused by checking the capillary water and condensing the water vapor in the soil. The moist layer is usually found from 10 to 18 inches below the surface, and the moisture so stored is readily available for plant use.

Evidence of the value of a saturated subsoil was gained in an experiment in which 2 pounds of water were added to a measured amount of surface soil. It was found that after 26 hours the soil so watered had gained 3 pounds of moisture, while the soil of twice the volume immediately below had lost 1¾ pounds. This would indicate that a moist subsoil is a material aid to rainfall under normal conditions, but little or no such aid can be expected this year. Because of the dryness of the soil it is far more probable that percolation will more than offset the forces of capillarity, thus making it imperative to have adequate and timely rainfall.

During a six weeks' drought in continental Europe in 1892, fruit trees failed to mature fruit, and many trees did not recover the following year. At the same time in California the normal dry season of from four to five months did not harm the orchards, as they produced a normal crop and without the aid of irrigation; surface tillage was used to conserve moisture. The trees in Europe were shallow rooted and depended on frequent rains, while those in California were deep rooted and could stand long periods of drought. Perennials in the dry-farming sections of the United States generally draw heavily on the subsoil moisture.

The amount of water evaporated by a growing crop is so great that it is practically certain that all the moisture is not usually secured by one season's rainfall. The amount necessary to mature a crop has been variously estimated at from two hundred to eight hundred times the amount of dry matter produced. Moreover, experiments have shown that plants that have taproots use little moisture from the surface soil and these require an abundant supply from the subsoil. A crop that uses surface soil moisture for plant evaporation required heavier and more frequent rains.

CORRELATION BETWEEN WEATHER AND PUNJAB WHEAT

Volume XXV, part 4 of the memoirs of the Indian Meteorological Department (Calcutta, 1929, p. 145–161, 2 pl.), is devoted to an article on Correlation Between Weather and Crops with Special Reference to Punjab Wheat by Rao Saheb Mukund V. Unakar.

The purpose of this study is to show the results of the research being done by the Indian Meteorological Department on the problem of wheat crop prediction in the Punjab.

In this section of India, wheat is sown in October and November, while the harvesting ends by the middle of April following. The authors make several predictions during this period, one at the end of each of the months of September to March. They have worked out correlation coefficients which take into account the meteorological elements of total Punjab rainfall, Lahore maximum temperatures, and Indus River levels, and the wheat elements of area sown, gross yield, and per acre yield. The Indus River level factor is included because nearly half the area of wheat sown in the Punjab is irrigated.

Tables show correlation coefficients for the various factors involved at different months of the growing season, and charts indicate graphically the degree of accuracy attained by crop predictions based on the meteorological factors. However, no figures other than correlation coefficients were shown which would indicate the percentage error of the crop predictions. These figures, together with a reduction of the amounts of production to bushels, seem essential to a better evaluation of the work being done by the Meteorological Department. To obtain this knowledge, and also to learn the degree of accuracy shown by the official estimates, the writer has taken the figures given in Table 8 and found the following results.

Over a period of 12 years the Meteorological Department's prediction in January showed an error of 12.8 per cent from the actual yield; its error on the March prediction amounted to 11.7 per cent. That of the official estimate showed an error of 6.9 per cent, but this prediction was made at the middle of April after the harvest. The figures just cited are obtained from averages over the whole 12-year period. The closest prediction of the Meteorological Department was within 1,000,000 bushels of the actual yield for the area studied, which totaled 126,600,000 bushels. This prediction was made in March, 1923, for the crop to be harvested in April. The closest official estimate of the Department of Agriculture was within 333,000 bushels of the actual yield, and this prediction was made in April, 1916. The greatest error made by the Meteorological Department during the 12-year period was that of their March, 1922 prediction, which was 27,500,000 bushels too low. But this error was exceeded by the official Department of Agriculture prediction made the middle of April, 1923, which was 37,400,000 bushels too high. Three of the 24 predictions made by the Meteorological Department showed a departure opposite that to the actual, while none of the 12 official Agricultural Department predictions showed such an error.

Forecasts for area sown made by the Meteorological Department and the Official Forecasting Agricultural Department for the same period of years show the following errors:

	Per cent
Average Meteorological Department error	4.5
Average Official error	5.2
Greatest Meteorological Department error	11.7
Greatest Official error	8.7
Least Meteorological Department error	.9
Least Official error	1.9

Two of the 12 predictions on area sown made by the Meteorological Department showed a departure opposite that of the actual, while none of the 12 official predictions showed such an error. The Meteorological Department predictions were made the last of October, while those of the Official Department came out the last of January.

These errors [while somewhat greater than those of some investigations of the United States Weather Bureau in Weather and Crop Studies of this Country] are small enough to indicate that the work of the Indian Meteorological Department is of significant value to Indian agriculture. Probably its greatest value comes through the fact that these predictions are made known so much earlier than the official estimates. Doubtless when other meteorological factors such as frost frequency, distribution of rainfall, cloud proportion, dust storms, and direction of prevailing wind are included by the Indian Meteorological Department in their corrections, their estimates will much more closely approach the actual.—*Earl B. Shaw,* Clark University.

E. KIDSON ON AVERAGE ANNUAL RAINFALL IN NEW ZEALAND FOR THE PERIOD 1891 TO 1925 [1]

The distribution of precipitation in New Zealand is affected by topography and the prevailing westerly winds in such manner that most rainfall occurs on the west sides of the islands. Rain shadows are noticeable in the central portions. The east shore has a higher precipitation than the central area on account of onshore winds. However, there is a tendency for the lowest rainfall to occur near the coast in the neighborhood of Cape Campbell. The highest precipitation is in the western highlands of both islands, over 200 inches, the lowest in the southeastern lowland of South Island, under 15 inches. The number of rainy days is practically nowhere excessive.

The accompanying five maps showing in detail the distribution of stations, relief, average number of rainy days, and mean annual rainfall of the Islands add greatly to the value of the work.—*Sigismond R. Diettrich.*

[1] Meteorological Branch, Department of Scientific and Industrial Research, Wellington, New Zealand, 1930, pp. 8, 5 maps.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 1930

Three papers of meteorological interest presented at the Bristol meeting, 1930, are noted in the report of the meeting, just published.[2]

A discussion on The Meteorological Relations of Atmospherics, by R. A. Watson Watt, E. V. Appleton, R. Bureau, and M. A. Giblett, is briefly outlined (p. 293). Mr. Watt outlined the present knowledge of the subject; Mr. Bureau described the recording of the number of atmospherics per minute. Professor Appleton compared extraterrestrial with terrestrial sources, concluding that—

> The thunderstorm mechanism seems to be a more likely source than the extraterrestrial sources proposed.
>
> Attention is called to the experimental fact found by Appleton, Watt, and Herd that, for atmospherics of local origin, negative electrostatic field changes are about 1.5 times as frequent at positive, while for those of distant origin positive radiation field changes are about 1.5 times as freqeunt as negative. The possible significance of this is briefly discussed.

Mr. Giblett said that observations of the sources of atmospherics made at the radio research station, Slough, Bucks, at 13.00 G.M.T. daily had been plotted and studied in connection with the current synoptic charts.

The abstracts of two papers on climatic changes follow (p. 349):

Dr. C. E. P. Brooks, Climatic Changes in Historic Times.

> It appears probable that there have been during historic times certain periods when the climate of large areas differed appreciably from that of the present century. The conditions are discussed during a number of critical periods, as far as the available evidence permits:
>
> ca. 2200 B. C. Dry in Europe and western Asia. In western and central Europe the rainfall was in places only about half the present amount.
>
> 800–400 B. C. Wet and stormy, especially in central Europe.
> 0–200 A. D. Approaching present conditions.
> 500–800 A. D. Probably rather dry, especially in central Asia.
> 1200–1400 A. D. Wet and stormy in northwestern Europe.
> 1700–1750 A. D. Dry in western Europe.

Prof. A. E. Douglass, Past Changes in Climate in Relation to Settlements in the New World.

> The annual rings of trees provide a means of studying certain characters of past climates. In the southwestern parts of the United States showing an annual rainfall of 15 to 25 inches, the rings of the *Pinus ponderosa* give a very effective record of rainfall variations from year to year, increased growth accompanying increased rainfall. Long series of such ring values have been studied and variations have been found related to the 11-year sun-spot cycle.
>
> Since, in the region referred to, the climate is fairly constant over a large area, annual characters in rings may be traced over an extended forest district and thus exact dates may be carried from tree to tree. For example, we can pass from the older central part of a living tree to the outer part of an old building beam in a village 100 miles away, and then from the central part of the latter beam to the outer part of, perhaps, a log from a distant prehistoric ruin. Thus, a chronology of rings and rainfall has been carried back to 700 A. D. But this exact dating of the rings gives also the actual years of cutting the logs provided the outermost rings are still present. Thus, in return for providing material for building a climatic history the archæologists have received the building dates of some 40 prehistoric ruins. The oldest and the largest of the ruins so far dated, is Pueblo Bonito (New Mexico) whose construction period extended from 919 to 1127 A. D. The method can be successfully applied in many parts of the world but not necessarily in all.—*C. F. B.*

[2] British Association for the Advancement of Science. Report of the Ninety-eighth Meeting (Hundredth Year), Bristol, 1930, September 3–10. London, Office of the British Association, Burlington House, London, W. 1, 1931. 472 pp.